

Accepted Manuscript

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PII: S0304-3932(19)30118-7
DOI: <https://doi.org/10.1016/j.jmoneco.2019.07.001>
Reference: MONEC 3132

To appear in: *Journal of Monetary Economics*

Received date: 2 August 2017
Revised date: 3 July 2019
Accepted date: 3 July 2019

Please cite this article as: Galip Kemal Ozhan, Financial Intermediation, Resource Allocation, and Macroeconomic Interdependence, *Journal of Monetary Economics* (2019), doi: <https://doi.org/10.1016/j.jmoneco.2019.07.001>

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Financial Intermediation, Resource Allocation, and Macroeconomic Interdependence[☆]

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Abstract

During the first decade of the euro, southern countries experienced a boom-bust cycle in bank lending, non-tradable sector growth, and capital inflows. I develop a quantitative, open economy model of banking that is consistent with the banks' behavior in credit allocation and foreign borrowing observed in Spanish data. I illustrate how movements in the frictions of cross-border deposits generate an endogenous asymmetric allocation of bank credit toward non-traded sectors, while producing a persistent and climbing current account deficit. A common central bank's unconventional policies in response to sudden stops are successful at ameliorating the downturn.

JEL Classification: E44, F32, F41, G15, G21.

Keywords: Bank Credit, Sectoral Allocation, Deposits, Capital Flows, Europe.

Highlights:

- This paper studies the role of the financial sector in an open economy.
- The model is successful at capturing the Spanish data between 2000-2010.
- Movements in the credit frictions lead to intra-national and international imbalances.
- A banking and a trade channel are at work in generating data consistent dynamics.
- The model with unconventional policies demonstrates a milder bust.

[☆]The paper is based on the first chapter of my doctoral dissertation. I cannot thank enough to Fabio Ghironi for his invaluable guidance. I am also grateful for comments and suggestions from Urban Jermann and an anonymous referee. I further benefited from discussions with Philippe Bacchetta, Ben Bernanke, Roy Cerqueti, Yu-chin Chen, Kemal Derviş, Francesco Giavazzi, Refet Gürkaynak, Galina Hale, Tom Holden, Nobuhiro Kiyotaki, Federica Romei, Harald Uhlig and Andrei Zlate, as well as participants at numerous seminars and conferences.

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1. Introduction

Following the creation of Europe's Economic and Monetary Union (EMU), large capital flows from Eurozone core to periphery were channeled through the banking sector. Financial institutions in southern countries experienced an unprecedented growth in their loan portfolios (e.g., Giavazzi and Spaventa, 2010) which was largely backed by foreign deposits.¹ A big portion of these loans was directed toward domestic non-traded sectors—construction and services. This contributed to an asset price boom, especially in the non-traded sectors, and led to an increase in wages and costs in a way that harmed export competitiveness, further worsening current account positions. The “rose garden” feeling disappeared with the Global Financial Crisis (GFC). It alerted authorities and public opinions in the Eurozone to the possibility of large violations of rules by other countries, and cross-border capital flows stopped quickly. Bank lending, investment, and output collapsed; the spreads between lending and risk-free rates rose steeply.

To shed light on the link between bank lending, sectoral resource allocation, and external imbalances, I develop a quantitative two-country macroeconomic model with a financial sector in which banks lend funds to be invested in tradable or non-tradable sector capital and borrow from households in both countries. A decline in the frictions applying to cross-border deposits in domestic bank balance sheets generates the boom part of the cycle, and later, an instantaneous correction in the cross-border deposit frictions triggers the bust.² The goal is to have a model that not only explains boom-bust periods when bank balance sheets are large but also capture the role of bank balance sheet composition and international factors in shock transmission and propagation within and across countries.

The model stands on the work on incomplete market models of international business cycles, such as Benigno and Thoenissen (2008) and Corsetti, Dedola, and Leduc (2008), and the work on closed economy models with financial intermediation, as Gertler and Karadi (2011) and Gertler and Kiyotaki (2010) (GKa and GK_i, henceforth).³ The model extends the agency problem in the latter literature and allows intermediaries to hold a portfolio of assets from different sectors and borrow from both domestic and foreign savers. As in Gertler-Karadi-Kiyotaki models, financial intermediaries can divert a fraction of assets that are funded by deposits. However, the ability of diverting assets that are funded by foreign creditors might differ from diverting those funded by domestic creditors. In addition, it is more difficult for depositors to monitor the performance of financial claims from the non-traded sector vis-à-vis to monitoring tradable sector assets.⁴ The joint analysis of financial shocks and the heterogeneity in bank balance sheets yields new insights on the transmission and propagation of fluctuations between sectors and across countries.

Simulations indicate that the model can generate persistent current account deficits with endogenously increasing banking exposure to the non-traded sector following reductions in the financial frictions of cross-border deposits, and a sudden reversal of capital flows and an overall collapse in aggregate output through elevated borrowing costs of non-financials when the degree of frictions get back to their initial level. The model thus provides a rigorous framework for the emerging consensus on the Eurozone crisis as the outcome of financial intermediation, resource allocation, and a reversal of capital flows (e.g., Baldwin and Giavazzi, 2015).

A novel mechanism, that is a product of *banking* and *trade* channels that reinforce each other, operates in generating fluctuations. The *banking channel* prevails as reductions in cross-border deposit frictions contribute to capital inflows and credit expansion. Credit to the non-traded sector becomes cheaper due to relative difficulty in monitoring that asset class, and non-traded sector firms start to demand more bank funding, contributing to an asymmetric growth in the non-traded sector share of the economy. Furthermore, the endogenous divergence in intersectoral credit allocation and in the relative shares of sectors in overall economy is exacerbated by a *trade channel*, independent from the heterogeneity in bank assets. A decline in domestic real interest rates in response to diminishing cross-border deposit frictions drives asset and consumption prices up, making domestically produced goods more expensive. Consumers shift their expenditure to imports and push domestic traded good production down. Hence, irrespective of the heterogeneity among different asset classes in bank portfolios, capital inflows generate intra-national imbalances, through a trade effect. When both effects are in place, they reinforce each other and the model produces a data consistent outcome.

¹For instance, in Spain, only about 45 percent of total deposits in Spanish financial institutions were from the residents in 2007:QIV (e.g., Santos, 2014).

²The shock can be interpreted as a boost in international creditor confidence to domestic financial sector. Giavazzi and Spaventa (2010) highlight that, after the inauguration of the euro, the perception within the EMU was no individual country would be subject to speculative attacks and therefore, the Eurozone was contributing to a sound financial sector.

³Although the model incorporates key features of these literatures, it is not a direct merger of the papers indicated above. As highlighted in the main text, asymmetries in bank portfolio, foreign liabilities of financial sector, and movements in international prices are crucial for capturing data consistent model outcome.

⁴This assumption captures the fact that securitization associated with non-traded sector assets made the financial system obligations more opaque (e.g., Brunnermeier, 2008, and Jimenez et al., 2010). Further discussion can be found in Section 3.1.

I also use the model to study unconventional monetary policy conducted by a common central bank for the two countries in the model, and I show that policies reminiscent of those implemented by the European Central Bank (ECB) help mitigate the adverse effects of sudden reversal of international capital flows. The model with policy does a better job at capturing the post-crisis data behavior, suggesting policy is the missing ingredient during the bust regime.

In addition to the literatures on international business cycles and closed economy macro models with financial intermediation, this paper contributes to three other literatures. First, since the non-traded sector in my model includes housing, the paper contributes to the literature that argue capital inflows drive asset prices in recipient economies.⁵ This paper differentiates itself by modeling an explicit financial sector that optimizes over an infinite horizon and studying unconventional policy in response to sudden reversal of capital flows.

Second, the paper contributes to a recently growing literature that investigates the role of financial intermediation in open economies.⁶ This paper mainly distinguishes itself from previous models by two characteristics. First, the model distinguishes between differentiated goods produced in each country and assumes the existence of internationally incomplete financial markets through the banking sector. Second, the model features two sectors that are dependent on bank funding. The first feature implies a role for international relative prices, which interact with accumulation of foreign assets in internationally incomplete markets (bank deposits) in shaping the transmission of shocks between countries through banking. The second feature allows for asset heterogeneity within each economy. Banks hold a portfolio of assets from both sectors, and their optimization problem leads to an additional channel for shock transmission across sectors.

Third, the paper distinguishes itself from the literature that studies the effect of financial frictions in a macroeconomic setting by the description of the shock. The shock is linked with both international and financial aspects of the model.⁷ Specifically, I characterize the boom period as a reduction in the financial frictions of cross-border deposits, and the bust, by moving this friction back to its initial value.

To my knowledge, this paper is also the first to study central bank asset purchases and liquidity facilities in a boom-bust scenario.

The rest of the paper is organized as follows. Section 2 presents the model. Section 3 discusses the outcome of the model without policy, when calibrated to a standard open economy. Section 4 describes the central bank's unconventional policy and discusses its results. Section 5 concludes.

2. Model

I start with presenting the physical setup—a no-distortion two-country model, which allows non-tradable inputs in the production process—and then, I add financial frictions within and across countries. The setup of the model assumes that the law of one price holds, and sources of PPP deviations are home bias in preferences and the presence of non-traded goods in the economy. Banks are channelling funds from households (savers) to non-financial firms (borrowers), and their ability of intermediation is limited due to a moral hazard problem which is explained in the following sections. Banks are able to raise deposits from households in both countries, and provide funding to domestic two non-financial sectors.⁸

In what follows, I focus on Home economy and, otherwise indicated, Foreign is symmetric.

2.1. Physical Setup

The world is composed of two countries, Home and Foreign. Foreign variables are denoted with an asterisk. Each country is populated by a unit mass of atomistic households with some fraction supplying labor to tradable and non-tradable intermediate good production.

Non-financial firms in tradable and non-tradable sectors produce output using a Cobb-Douglas production function which combines capital and labor:

$$Y_{i,t} = F(K_{i,t}, L_{i,t}) = K_{i,t}^\alpha L_{i,t}^{1-\alpha} \quad i \in \{T, NT\}, \quad (1)$$

where subscript T denotes the tradable sector variables, and NT denotes non-tradable sector variables.

⁵Among others, this literature includes Coimbra (2010), Cesa-Bianchi et al. (2016), Punzi (2013).

⁶See Cacciatore et al. (2014), Dedola et al. (2013), Kollmann et al. (2010), Mendoza and Quadrini (2010), Nuguer (2016), and Reis (2013).

⁷Among others, Del Negro et al. (2017) and Jermann and Quadrini (2012) use a similar mechanism to motivate disruption in financial markets in a closed economy setting, and Dedola et al. (2013) conduct experiments with financial shocks without distinguishing cross-border deposits.

⁸I focus on a real model, because this setting is sufficient to generate the importance of financial market frictions on real activity. It is straightforward to extend the model to allow standard frictions in the literature, such as wage rigidity, price and wage indexation, et cetera.

There are two types of capital producers, each of them producing capital for a respective sector. The law of motion of capital for each capital producer is subject to convex adjustment costs, and in the aggregate they follow the process:

$$K_{i,t+1} = (1 - \delta)K_{i,t} + I_{i,t} - f\left(\frac{I_{i,t}}{K_{i,t}}\right)K_{i,t} \quad i \in \{T, NT\}, \quad (2)$$

where $f(\bullet)$ denotes the convex adjustment costs.

Non-financial goods producers obtain capital for the use in the next period by issuing claims $S_{i,t}$, at the price of the capital, $Q_{i,t}$. By the assumption of no-arbitrage, value of claims should be equal to the value of capital bought by non-financials:

$$Q_{i,t}K_{i,t+1} = Q_{i,t}S_{i,t} \quad i \in \{T, NT\}. \quad (3)$$

The representative household consists of a family, in which workers in the family are divided into two, each group supplying labor to firms for tradable or non-tradable goods production. The whole family jointly maximize an inter-temporal utility function that derives utility from household's consumption of basket of goods, C_t , and disutility from supplying labor to tradable and non-tradable good production, $L_{T,t}$ and $L_{NT,t}$, respectively:

$$U(C_t, L_{T,t}, L_{NT,t}) = \frac{C_t^{1-\rho}}{1-\rho} - \varpi \left(\frac{L_{T,t}^{1+\varphi_1}}{1+\varphi_1} + \frac{L_{NT,t}^{1+\varphi_2}}{1+\varphi_2} \right). \quad (4)$$

Within this setting, relative hours spent respond less to sectoral wage differentials due to sector specificity.

Households enjoy consumption of an Armington aggregate of composite tradable and non-traded goods. The final consumption aggregate is given by,

$$C_t = \left[a_T^{1/\kappa} C_{T,t}^{(\kappa-1)/\kappa} + (1 - a_T)^{1/\kappa} C_{NT,t}^{(\kappa-1)/\kappa} \right]^{\kappa/(\kappa-1)}, \quad (5)$$

where $C_{T,t}$ is the consumption of the composite traded good, and $C_{NT,t}$ is the consumption of non-traded good. The parameter a_T denotes the share of tradables in final consumption, and κ is the intratemporal elasticity of substitution between tradable and non-tradable goods.

The composite tradable good is also an Armington aggregate of Home and Foreign produced traded goods:

$$C_{T,t} = \left[a_H^{1/\omega} C_{H,t}^{(\omega-1)/\omega} + (1 - a_H)^{1/\omega} C_{F,t}^{(\omega-1)/\omega} \right]^{\omega/(\omega-1)}, \quad (6)$$

where $C_{H,t}$ is the consumption of the traded good produced in Home, and $C_{F,t}$ is the consumption of the traded good produced in Foreign. The parameter ω is the intratemporal elasticity of substitution between Home and Foreign goods, and there is home-bias in consumption if $a_H > \frac{1}{2}$.

Market clearing in each sector requires that Home production equals Home and Foreign consumption, and investment:

$$Y_{T,t} = C_{H,t} + C_{H,t}^* + I_{T,t}, \quad Y_{NT,t} = C_{NT,t} + I_{NT,t}. \quad (7)$$

This frictionless economy is the bare-bone model. In what follows, I focus on the decentralized economy, and introduce financial frictions that will impede flow of funds within and across countries.

2.2. Households

The representative household in each country consists of a fraction of g bankers, and $1 - g$ workers. Bankers manage financial intermediaries and transfer their earnings back to the household, and workers similarly return their income back to the household. Households do not provide funds to non-financial firms nor do they acquire capital. They deposit funds to financial intermediaries that they are not related with, and therefore there is perfect consumption insurance within the household. Intermediaries raise funds from households only by offering non-contingent risk-less short term debt (deposits).

Households maximize expected inter-temporal utility from consumption, C_t , net of disutility from providing labor to traded and non-traded sectors, $L_{T,t}$ and $L_{NT,t}$, as given by $\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(C_t, L_{T,t}, L_{NT,t})$, where $U(\bullet)$ is expressed in (4).

Households in each country hold one-period deposits supplied by Home and Foreign intermediaries. I assume that deposits pay risk-free consumption-based real returns. Households enter period t with deposits of Home and Foreign intermediaries, B_t and $\xi_t B_{*,t}$, in units of home consumption, where ξ_t represents the real exchange rate.⁹

⁹Similarly, Foreign households hold deposits at Foreign and Home intermediaries, which are denoted as $B_{*,t}^*$ and $\frac{B_t^*}{\xi_t}$, in terms of Foreign consumption units.

They receive gross income on deposits and labor income, and allocate these resources between consumption and purchases of deposits to be carried next period. The period budget constraint in units of consumption is

$$C_t + B_{t+1} + \xi_t B_{*,t+1} + \frac{\eta}{2} \xi_t (B_{*,t+1})^2 = R_t^H B_t + \xi_t R_t^{H*} B_{*,t} + w_{T,t} L_{T,t} + w_{NT,t} L_{NT,t} + \Pi_{T,t} + \Pi_{NT,t} + \Pi_{B,t} + T_t^{f*} + T_t, \quad (8)$$

where $\frac{\eta}{2} \xi_t (B_{*,t+1})^2$ is the cost of adjusting holdings of Foreign deposits, R_t^H and R_t^{H*} are gross interest rates received after holding Home and Foreign deposits, respectively. T_t^{f*} is the fee rebate, taken as given by the household, and equal to $\frac{\eta}{2} \xi_t (B_{*,t+1})^2$ in the equilibrium, and T_t is the lump-sum transfers. The representative Foreign household faces a similar constraint in units of foreign consumption. Introducing convex adjustment costs ensures that zero foreign deposit holding is the unique steady state, and hence economies go back to their initial position after temporary fluctuations.¹⁰ $\Pi_{T,t}$, $\Pi_{NT,t}$, and $\Pi_{B,t}$ represent the profits back to household by traded and non-traded sector workers, and intermediaries, respectively.

Home household maximizes expected discounted utility subject to (8). The Euler equations for deposit holdings at Foreign and Home intermediaries are

$$C_t^{-\rho} [1 + \eta B_{*,t+1}] = \beta R_t^{H*} \mathbb{E}_t \left[\frac{\xi_{t+1}}{\xi_t} C_{t+1}^{-\rho} \right], \quad (9)$$

$$C_t^{-\rho} = \beta R_t^H \mathbb{E}_t [C_{t+1}^{-\rho}]. \quad (10)$$

With $\eta > 0$, no-arbitrage condition¹¹ implies:

$$\frac{R_t^H}{R_t^{H*}} = \frac{\mathbb{E}_t \left[\frac{\xi_{t+1}}{\xi_t} C_{t+1}^{-\rho} \right]}{(1 + \eta B_{*,t+1}) \mathbb{E}_t [C_{t+1}^{-\rho}]}$$

Consumption-labor trade-offs are given by $w_{T,t} = \frac{\varpi L_{T,t}^{\varphi_1}}{C_t^{-\rho}}$, and $w_{NT,t} = \frac{\varpi L_{NT,t}^{\varphi_2}}{C_t^{-\rho}}$. They ensure that the marginal rate of substitution between consumption and leisure is equal to the respective wage rate in each sector.

Given (5) and (6), demand curves for traded Home good are $C_{H,t} = a_H \left(\frac{P_{H,t}}{P_{T,t}} \right)^{-\omega} C_{T,t}$ and $C_{H,t}^* = (1 - a_H) \left(\frac{P_{H,t}}{\xi_t P_{T,t}^*} \right)^{-\omega} C_{T,t}^*$, where P_H , P_T and P_T^* denote the relative prices of Home traded goods, composite traded goods, and Foreign composite traded goods. The conditions for the Foreign traded goods are analogous.

Similarly, the generic demand curve for Home non-traded and composite traded goods are given by $C_{NT,t} = (1 - a_T) (P_{NT,t})^{-\kappa} C_t$ and $C_{T,t} = a_T (P_{T,t})^{-\kappa} C_t$.

2.3. Firms

There are two types of producers in each sector, namely goods producers and capital producers.

2.3.1. Goods Producers

Goods are produced under perfect competition in both sectors. The production technology at time t is given as a constant returns to scale function, $F(K_{T,t}, L_{T,t})$ for tradable good producers, and $F(K_{NT,t}, L_{NT,t})$ for non-tradable good producers as in (1).

Firms finance their capital expenditures in each period by issuing claims. Firms derive revenues from selling their good and selling the undepreciated portion of the physical capital back to capital producers, after production. On the cost side, they pay laborers and pay intermediaries interest for the claims $S_{i,t-1}$. Marginal product of capital is as standard in the literature, and given by $Z_{i,t} \equiv \frac{P_{i,t} Y_{i,t} - w_{i,t} L_{i,t}}{K_{i,t}} = P_{i,t} F_{K_{i,t}}(K_{i,t}, L_{i,t})$, where $i \in \{T, NT\}$ and $ii \in \{H, NT\}$.

Banks can perfectly monitor and evaluate the non-financial firms, and hence, every financial contract between the non-financials and intermediaries delivers its promises. Goods producing firms obtain zero profits state-by-state, and the ex-post return on capital is fully paid out to the financial intermediary. Accordingly, ex-post return on capital in tradable and non-tradable sectors are:

$$\beta \mathbb{E}_t [\Lambda_{t,t+1} R_{k,i,t+1}] = \beta \mathbb{E}_t \left[\Lambda_{t,t+1} \left(\frac{Z_{i,t+1} + (1 - \delta) Q_{i,t+1}}{Q_{i,t}} \right) \right], \quad (11)$$

¹⁰It will be clear when studying the banking sector that Home deposit holding is pinned down with the deposit market clearing condition and it is non-zero in the steady-state. Hence, there is no need for a convex adjustment cost for Home deposits to ensure that it has a unique steady state.

¹¹Introducing time varying frictional costs for cross-border deposits implies a wedge between R^H and R^{H*} in equilibrium, and introduce another mechanism in violating the uncovered interest parity condition, in addition to incomplete international markets.

where $\Lambda_{t,t+1} = \frac{U_C(t+1)}{U_C(t)}$.

The interest paid out to the intermediary varies with the marginal product of capital and with the fluctuations in prices. The latter is due to the transaction with capital producers. In each sector, firms also choose labor demand as follows:

$$w_{i,t} = P_{ii,t} F_{L_i}(K_{i,t}, L_{i,t}). \quad (12)$$

Labor demand conditions state that the marginal product of labor in each sector should be equal to the respective wage rate.

2.3.2. Capital Producers

Capital producers produce new capital that will be used by goods producers in the subsequent period. They decide for investment after buying the used capital from goods producers. The price of capital is equal to the marginal cost of investment goods production:

$$Q_{i,t} = \frac{1}{1 - f_I(\frac{I_{i,t}}{K_{i,t}})K_{i,t}}. \quad (13)$$

Capital adjustment costs cause asset prices to deviate from unity and contribute to the financial accelerator mechanism as standard in the literature.

2.4. Financial intermediaries

Financial intermediaries obtain funds from both Home and Foreign households, and lend to domestic firms operating in traded and non-traded sectors. Moreover, intermediaries can raise funds through their own net worth (bank capital), which is accumulated through their earnings.

The value of funds extended to each sector is equal to the price, $Q_{i,t}$, times the quantity of claims on non-financial firms held by intermediary j , $S_{i,t}(j)$. Intermediaries fund their assets by their own net worth and the total amount of deposits raised from Home and Foreign households. Hence, the intermediary balance sheet takes the following form:

$$\underbrace{Q_{T,t}S_{T,t}(j) + Q_{NT,t}S_{NT,t}(j)}_{\text{Assets}} = \underbrace{B_{t+1}(j) + B_{t+1}^*(j)}_{\text{Liabilities}} + \underbrace{N_t(j)}_{\text{Bank capital}} \quad (14)$$

Let R_t^F be the interest rate from $t-1$ to t that is paid out to Foreign households. The earnings of an individual Home intermediary j in period t is the payoff from total assets funded in the previous period net of cost of deposits raised from Home and Foreign:

$$N_t(j) = R_{k,T,t}Q_{T,t-1}S_{T,t-1}(j) + R_{k,NT,t}Q_{NT,t-1}S_{NT,t-1}(j) - R_t^H B_t(j) - R_t^F B_t^*(j) \quad (15)$$

To rule out the possibility of intermediaries' accumulating enough wealth to end their need to raise funding from households, intermediaries are assumed to be finitely lived. Each period, with probability $1 - \gamma$, bankers switch occupations. Exiting bankers bring their end-of-period bank capital back to their household, and entering bankers receive funding right before they start business. Thus, every period $(1 - \gamma)g$ intermediaries exit and enter, and the number of workers and bankers is kept unchanged. Accordingly, the bankers' objective is to maximize their terminal net worth, which is the net present value of future earnings, before they exit: $V_t = \mathbb{E}_t \left[\sum_{s=1}^{\infty} (1 - \gamma) \gamma^{s-1} \beta \Lambda_{t,t+s} N_{t+s}(j) \right]$.

Following GKA, GKi, and as earlier in Holmström and Tirole (1997), there exists an agency problem between intermediaries and households. After collecting deposits, intermediaries can divert funds to the household that they are a member of. In this case, depositors can force the intermediary into bankruptcy and recover a fraction of the assets that the intermediary is holding. The fraction that can be recovered depends on the type of asset. Creditors retrieve $1 - \lambda_{NT}$ of non-traded and $1 - \lambda_T$ fraction of traded sector assets in the event of bankruptcy. Moral hazard restricts the amount lent by households, but the tightness of the constraint in domestic and foreign deposit markets might differ. In particular, intermediaries face additional difficulty in diverting assets that are funded by foreign deposits.

Let $V_t(N_t(j))$ be the maximized value of V_t , given intermediaries' period retained earnings. The following incentive constraint will suffice to prevent intermediaries to run away with their assets:

$$V_t(N_t(j)) \geq \lambda_T [Q_{T,t}S_{T,t}(j) - \iota_t B_{t+1}^*] + \lambda_{NT} [Q_{NT,t}S_{NT,t}(j) - \iota_t B_{t+1}^*]. \quad (16)$$

The variable ι_t denotes the relative degree of friction applying to foreign deposits, and variation in it can be interpreted as fluctuations in international confidence in Home financial sector. At the end of period $t-1$, the

intermediary's program becomes

$$V_{t-1}(N_{t-1}(j)) = \mathbb{E}_{t-1} \left[\beta \Lambda_{t-1,t} \left\{ (1 - \gamma) N_t(j) + \gamma \left(\max_{S_{T,t}, S_{NT,t}} \left(\max_{B_{t+1}^*, B_{t+1}^*} V_t(N_t(j)) \right) \right) \right\} \right] \quad (17)$$

subject to (14), (15), and (16).

I guess and verify that the banks' value function is linear in their net worth, *i.e.* $V_t(N_t(j)) = v_t N_t(j)$. First order necessary conditions for the intermediary problem yield

$$\beta \mathbb{E}_t \left[\Lambda_{t,t+1} \Omega_{t+1} (R_{k,T,t+1} - R_{t+1}^H) \right] = \mu_t \lambda_T, \quad (18)$$

$$\beta \mathbb{E}_t \left[\Lambda_{t,t+1} \Omega_{t+1} (R_{k,NT,t+1} - R_{t+1}^H) \right] = \mu_t \lambda_{NT}, \quad (19)$$

$$\beta \mathbb{E}_t \left[\Lambda_{t,t+1} \Omega_{t+1} (R_{t+1}^F - R_{t+1}^H) \right] = \mu_t (\lambda_T + \lambda_{NT}) \iota_t, \quad (20)$$

with

$$\mu_t = 1 - \left(\frac{\beta \mathbb{E}_t \left[\Lambda_{t,t+1} \Omega_{t+1} R_{t+1}^H \right] N_t}{\lambda_T [Q_{T,t} S_{T,t}(j) - \iota_t B_{t+1}^*] + \lambda_{NT} [Q_{NT,t} S_{NT,t}(j) - \iota_t B_{t+1}^*]} \right). \quad (21)$$

In the above conditions, μ_t is the Lagrangian multiplier associated with the banker's program; Ω_t is the shadow value of a unit of net worth to the banker at time t , which is given by $\Omega_t \equiv (1 - \gamma + \gamma v_t)$, averaging the exiting and continuation states; and v_t is the marginal value of net worth.¹²

Absent financial frictions, *i.e.* $\mu_t = 0$, bankers acquire deposits until the discounted cost of deposits is equal to the gain from lending to non-financial firms. The cost of Home and Foreign deposits are equal to each other as there is no asset diversion. In that case, banks' value function is equal to their net worth (*i.e.* $v_t = 1$), indicating an equivalence of the stochastic discount factors of agents in the economy (*i.e.* $\beta \Lambda_{t,t+1} = \beta \Lambda_{t,t+1} \Omega_{t+1}$). The differences between returns from non-tradable sector and tradable sector and between costs of Home and Foreign deposits vanish.

When intermediaries' incentive constraint binds, the spreads between the gains from lending to non-financial firms and the cost of borrowing from Home households are non-zero in the equilibrium, and they are scaled by the divertable proportion of assets in each sector. The magnitudes of spreads depend not only on how tight the incentive constraint is binding for the banker but also on the types of assets in the intermediary balance sheet.¹³ With $\lambda_{NT} > \lambda_T$, non-traded sector borrows initially at higher spreads.¹⁴ A relaxation in the financial constraint (*i.e.* μ_t going down) implies a greater fall in the non-traded sector interest rate spread vis-à-vis to traded sector spread. Therefore, in response to an increase in ι_t , intermediaries expand credit by more to the non-traded sector as it relaxes the incentive constraint by more, and non-traded sector firms demand more credit as it becomes cheaper.

The spread between the interest rate to Home and Foreign deposits depends on the degree of divertibility of assets funded by Foreign households, in addition to how tight the incentive constraint is binding. For a given value of μ_t , if it is harder to divert any assets backed by Foreign funding, $R_{t+1}^F - R_{t+1}^H$ increases accordingly. If there is no difference between Home and Foreign financing, interest rates paid out to Home and Foreign deposits are the same. The intuition behind positive spreads is that a unit of Foreign deposit allows Home intermediaries to expand assets by greater amount and intermediaries are willing to pay a premium for this advantage.¹⁵

The linearity of the value function helps us to write the incentive constraint in the following form:

$$\frac{(Q_{T,t} S_{T,t}(j) - \iota_t B_{t+1}^*(j)) + \frac{\lambda_{NT}}{\lambda_T} (Q_{NT,t} S_{NT,t}(j) - \iota_t B_{t+1}^*(j))}{N_t(j)} \leq \frac{v_t}{\lambda_T}. \quad (22)$$

When intermediary net worth is low, limits to arbitrage on intermediary portfolio leads to a maximum ratio of assets to net worth that satisfies the incentive constraint. In this case, the total amount of lending to non-financial firms is limited by the intermediary's net worth. Importantly, in this setting, a decline in the frictional costs of cross-border bank deposits (an increase in ι_t) also relax the leverage constraint for a given level of net worth,

¹²A detailed solution of the banker's problem is available in the Online Appendix.

¹³It is also useful to note that the heterogeneity in the divertibility of assets prevents the indeterminacy problem of intermediary portfolio allocation.

¹⁴As discussed in Section 3.1, this is a data consistent assumption.

¹⁵It is crucial to note that a change in the spread, $R_{t+1}^F - R_{t+1}^H$, is dependent both on how tight the incentive constraint is binding and on the degree of frictions applying to Foreign deposits. From (21), one can observe that, an increase in ι_t relaxes banks' constraint, by making it harder to divert assets funded by Foreign deposits, and from (20) it contributes to a positive spread between Home and Foreign deposit rates in the bank balance sheet, given μ_t . However, μ_t and ι_t affect (20) through opposite signs and the direction of the spread will depend on which effect is stronger. For plausible variations in ι_t , one should expect positive spread between $R_{t+1}^F - R_{t+1}^H$ in response to relaxation of bank constraints.

introducing an additional mechanism for the movements in the leverage constraint. Intermediaries are able to expand greater amount of assets as the confidence of international creditors arise.

Finally, the solution to the bankers' problem reads as marginal value of an additional bank net worth can be written in the following form:

$$v_t = \frac{\beta \mathbb{E}_t [\Lambda_{t,t+1} \Omega_{t+1} R_{t+1}^H]}{1 - \mu_t}. \quad (23)$$

The value from additional unit of net worth varies counter-cyclically. In the case of an economic downturn, bankers' incentive constraint gets tighter, sectoral spreads increase, and an additional unit of bank net worth becomes more valuable. Conversely, during the boom periods, bankers' incentive constraint relaxes, and the continuation value is lower than the previous case.

2.5. Equilibrium

Market clearing conditions in securities, deposits, goods and labor markets are required to close the model. The equilibrium in goods market in both sectors in Home is given by (7). A similar condition also holds in Foreign.

Market clearing for securities imply that the total supply of financial claims from firms is equal to the total amount of capital bought from respective sectors, as given in (3).

The equilibrium deposit market condition requires that total demand on deposits by Home and Foreign households should be equal to the aggregate bank assets net of bank net worth:

$$B_{t+1} + B_{t+1}^* = Q_{T,t} S_{T,t} + Q_{NT,t} S_{NT,t} - N_t. \quad (24)$$

Aggregate net worth is the sum of entering and existing bankers' net worth,

$$N_t = (\gamma + \varepsilon)[(Z_{T,t} + (1 - \delta)Q_{T,t})S_{T,t-1} + (Z_{NT,t} + (1 - \delta)Q_{NT,t})S_{NT,t-1}] - \gamma(R_t^H B_t + R_t^{H*} B_t^*), \quad (25)$$

where ε denotes the fraction of assets of exiting bankers, distributed back to entering bankers.

And, labor demand equals labor supply, implying:

$$P_{ii,t}(1 - \alpha)(K_{i,t})^\alpha L_{i,t}^{1-\alpha} = \varpi \frac{L_{i,t}^\varphi}{C_t^{-\rho}}. \quad (26)$$

Similar conditions hold also in Foreign.

Finally, under international incomplete markets, equilibrium allocation depends on the net foreign asset position at the beginning of each period. There is a net profit transfer from capital producers and bankers to the household that they are a member of. The profit of the banker is the assets taken upon exiting net of transfer to entrants.¹⁶

The equations (1, 2, 3, 7, 9, 10, 11, 12, 13, 18, 19, 20, 21, 23, 24, 25) together with respective demand and price equations, consumption-labor tradeoffs marginal product of capital, and their Foreign counterparts, in which (1, 2, 3, 11, 12, 13) have analogous components in traded and non-traded sectors, together with the net foreign asset condition determine the endogenous variables ($Y_{T,t}, Y_{NT,t}, K_{T,t+1}, K_{NT,t+1}, S_{T,t}, S_{NT,t}, C_t, C_{T,t}, C_{H,t}, C_{F,t}, C_{NT,t}, I_{T,t}, I_{NT,t}, L_{T,t}, L_{NT,t}, Z_{T,t}, Z_{NT,t}, R_{t+1}^H, R_{t+1}^F, R_{k,T,t}, R_{k,NT,t}, Q_{T,t}, Q_{NT,t}, P_{T,t}, P_{NT,t}, P_{H,t}, P_{F,t}, w_{T,t}, w_{NT,t}, \xi_t, v_t, \mu_t, N_t, B_{t+1}, B_{t+1}^*$) and their Foreign counterparts as a function of the state variables ($I_{T,t-1}, I_{NT,t-1}, K_{T,t}, K_{NT,t}, R_t^H B_t, R_t^{H*} B_t^*$) and their Foreign counterparts, together with the exogenous shock processes.

3. Model Calibration and Simulations

This section presents the numerical analysis from the simulations of the model. I start with discussing the calibration and then move to simulations to illustrate the model's success in capturing Spanish data. I further disentangle the channels at work to explain the transmission and propagation mechanisms.

3.1. Calibration

The depreciation rate, δ , capital share, α , households' discount factor, β , are set to their standard values in the literature, to 0.025, 0.33, and 0.995, respectively. With regards to the adjustment costs of foreign deposit holdings, η , I use 0.0025 as in Ghironi and Melitz (2005). Moreover, the inverse of the inter-temporal elasticity of substitution from consumption, ρ , is set to 2 as standard, and following GKa the inverse of the Frisch elasticities

¹⁶A detailed derivation of the net foreign asset position is available in the Online Appendix.

in traded and non-traded sectors, φ_1 are set to 0.276, and φ_2 to 0.276, and following GK1 the relative weight of labor in the utility, ϖ , is set to 5.584. The functional form of the capital adjustment costs is given by $\frac{\varphi^K}{2} \left(\frac{I_{i,t}}{K_{i,t}} - \delta \right)^2$ for every $i \in \{T, NT\}$. Following Bernanke, Gertler, and Gilchrist (1999), and φ^K is set to 5.

For the parameters that are of importance for the international dynamics, again, conventional values are used. The elasticity of substitution between Home and Foreign produced traded goods, ω , is set to 1.2 as in Ghironi (2006) among others, and following Obstfeld and Rogoff (2000) the elasticity of substitution between traded and non-traded goods, κ , is set to 1. The share of home-produced intermediate inputs in the tradable intermediate input, a_H , is fixed to 0.55, and share of tradables in the final consumption, a_T to 0.55, which are both in line with the Eurozone data.

Which is not standard in the literature is the calibration of this model's financial sector variables. The fractions of divertable capital in each sector, λ_T and λ_{NT} , are sector specific, and they capture the heterogeneity between financial claims in the bank balance sheet. I pick these parameters to hit the following targets: a home steady state interest rate spread in the tradable sector of 40 bps and a steady state interest rate spread in the non-tradable sector of 120 bps, implying a greater share of divertibility of non-traded sector assets. I choose a larger interest rate spread for the financial claims of non-tradables, for several reasons. Using mortgage loans as a proxy for non-traded sector credit, the differential spread between the 2003-2015 average mortgage rate and the rate on loans to non-financial corporations is positive.¹⁷ Moreover, securitization in non-traded sector related financial assets is linked with low lending standards, and makes the obligations of financial system more opaque (e.g., Brunnermeier, 2009), which provides justification for a higher λ_{NT} .¹⁸ In Spain, the increase in non-traded sector asset prices is linked with securitization of real estate assets, latter affecting the credit supply (e.g., Jiménez, et al., 2010 and Carbó-Valverde et al., 2012).^{19,20,21} To calibrate the steady state value of t_t , the steady state real interest rate spread between Home and Foreign deposits is set to 158bps, to match the difference between the 1993-1999 and 1999-2015 average of the short-term real interest rate spread between Spain and Germany, using OECD data. I also use a steady state leverage ratio in the range of values in the literature and set it to 6. Finally, my choices of the proportional transfers to entering intermediaries, ε , and the survival probability of intermediaries, γ , are in line with the literature. ε is set to 0.0001 and γ is fixed to 0.975, setting an average horizon of 10 years for intermediaries. Table 1 summarizes the parametrization.

3.2. Foreign Bank Financing and Macroeconomic Dynamics

In what follows, I discuss the performance of the model with respect to its abilities of capturing Spanish data, and then I identify the underlying channels at work by comparing dynamics when the heterogeneity in banking sector is turned on and off. Namely, calibrating $\lambda_{NT} = \lambda_T$ abstracts from the heterogeneity in banking sector and isolates the trade channel, whereas $\lambda_{NT} > \lambda_T$ allows banking channel to operate.

3.2.1. Specification

The main experiment, a decline in the frictional costs of cross-border bank deposits, is captured by movements in t_t . Given $t_t = \iota e^{\psi_t}$, the shock specification for the induction of model dynamics is as follows:

$$\psi_t = \rho_\psi \psi_{t-1} + \varepsilon_t,$$

where ε_t represents a white noise error in forecasting ψ_t that is based on its own past.

In line with my motivation of the recent boom-bust period in Southern Eurozone, I feed into the model a sequence of shocks to ε_t , each quarter allowing for a 50 percent reduction in the frictional costs of cross-border deposits from 1999:QIV up until the crisis in 2008:Q1, for 33 periods. The persistence is 0.99 because joining to the Eurozone was seen as an irreversible event.²² The crisis reveals itself as a loss of confidence of international creditors in Home financial conditions, and in period 33 there is a counteracting shock that takes t_t back to its 1999:QIV value. Hence, the crisis is induced by a sudden-stop of cross-border capital flows.

¹⁷The data is available from 2003. Sources are Bank of Spain and National Institute of Statistics (INE).

¹⁸Keys et al. (2010) also provide empirical evidence on the causal relationship from increased securitization to a decline in bank lending quality.

¹⁹According to these authors, although the size of securitization was negligible before the year 2000, the stock of securitized assets were about 30% of total bank credit in year 2008.

²⁰In a diff-in-diff setup (using Spanish data), the securitization related with non-traded sector assets is also associated with a more pronounced decrease in mortgage rates during the boom period. The link between securitization and non-traded sector boom-bust periods is recurrent in the history of financial crises such as the case in the central European crisis of 1931.

²¹As discussed in Section 3.2.3, $\lambda_{NT} > \lambda_T$ contributes to divergence in intersectoral bank lending.

²²The magnitude of persistence and the level of shocks contribute to the quantitative fit of the model dynamics to the data. Qualitative features are invariant under a milder process. In reality, there are also non-financial factors that affect the dynamics and a model that combines multiple drivers would allow for a milder shock process for the above specification to replicate several features of the data.

3.2.2. Model Performance

I investigate the ability of the model to match the Spanish data. Figure 1 compares generated model dynamics when there is a reduction in the frictional costs of Foreign deposits in Home bank balance sheet with the data.²³ Panel A plots Spain's current account-to-GDP ratio over the period 2000:Q1 to 2009:Q4 as deviations from 1999:Q4. The model variable is the current account. Panel B plots the percent deviation of lending of credit institutions to non-financial sectors in Spain (per GDP), normalized in 1999:Q4, and compares it with the model variables, $Q_T S_T$ and $Q_{NT} S_{NT}$. Purple line indicates lending to non-tradable sectors and blue line indicates lending to tradable. Panel C exhibits the share of non-traded sectors in overall gross value added as percent deviations from its 1999:Q4 value. The data consistent model variable is $\frac{Y_{NT}}{Y_T + Y_{NT}}$.

Reduction in the frictional costs of cross-border deposits induces an increase in the holdings of Foreign deposits of Home banks and generate an expansion of banking sector assets, while driving an endogenous skewed allocation towards non-traded non-financials and creating a boom in the non-traded sector, affecting its share in overall economy. The model reasonably captures the pattern of current account balance and the divergence in bank credit between traded and non-traded sectors during the boom era.

The shocks to cross-border deposit frictions enter through equations (20) and (21). From (21), it is observed that an increase in ι_t relaxes bank constraints, leading to a decrease in bank Lagrangian multiplier, μ_t . The decline in μ_t and the increase in ι_t create offsetting effects for the spread between Foreign and Home deposits in Home bank balance sheets, but the latter effect prevails, contributing to a positive spread. An increase in R_t^F attracts Foreign deposits and generates a persistent and climbing current account deficit. On the other hand, there is no offsetting effect for the spreads between lending and borrowing rates to non-financials, and a decline in μ_t triggers a decline in lending spreads. The decrease in the non-traded sector spreads is more pronounced as the moral hazard parameter for non-tradable, λ_{NT} , is larger, making credit to non-tradable cheaper. Hence, non-traded sectors demand more funding from intermediaries and credit allocation becomes asymmetric, contributing to increasing share of non-tradables in overall gross value added. In the data, non-traded sector receives more credit, possibly reflecting domestic factors, such as beliefs about future asset prices of domestic residents and over-investing asymmetrically in non-traded sectors, which is not studied in the model.

After 2008:Q1, with a sudden stop of cross-border bank finance, credit spreads in each sector jump and bank funding becomes more expensive. Due to higher fluctuations in credit spreads of non-traded sectors (due to the mechanism explained above), funding to non-tradables is reduced more heavily. Credit to the non-traded sector and the sector's relative share respond in a more pronounced manner vis-à-vis to the data after sudden reversal of capital flows. One of the reasons of a more pronounced bust is the absence of policy interventions by ECB in the current model. After unconventional policy is introduced into the model in the next section, it does a better job in capturing the post-crisis period.

The mechanism above is what I call the *banking channel*. To understand the separate roles of heterogeneity in banking and international prices, the next subsection presents counter-factual experiments when the heterogeneity between bank assets is turned on and off.

3.2.3. Three Model Versions

As discussed in the previous subsection, the model captures the key features of bank funding, sectoral allocation, and external borrowing of the Spanish boom-bust cycle. To further understand the contribution of heterogeneity in bank assets in generating these dynamics, three model versions are compared with each other.

All else being the same, I first set $\lambda_T = \lambda_{NT} = 0.1892$ by choosing a steady state spread of 20bps in each sector and call this version low lambda model. Then, I set $\lambda_T = \lambda_{NT} = 0.5627$ by choosing the steady state spreads equal to 120bps, and call this version high lambda model. In Figure 2, black lines show the dynamics from the former, and the purple lines show the dynamics from the latter. Blue lines show model dynamics for the baseline model.

One might expect similar movements in bank funding to both sectors when the moral hazard parameter is the same across sectors. However, it is not the case. Even in the absence of heterogeneity among different asset classes (*i.e.* $\lambda_T = \lambda_{NT}$), under the high lambda model, it is observed that banks extend more credit to non-traded sector, and under the low lambda model, more credit to traded sector. The reason is that movements in frictional costs of cross-border deposits affect the tightness of banks' incentive constraint in different magnitudes.

Under the high lambda model, banks' constraint relaxes less than the other cases. From equation (20), it can be observed that movements in ι_t offset the decrease in μ_t in a more pronounced manner and contribute to a larger spread between Foreign and Home deposits in bank balance sheets. Due to relative decline in Home interest rate, relative prices of Home tradable goods become more expensive and households shift their consumption of Home traded good with imported goods. This contributes to a larger current account deficit and shrinks the size of Home traded sector, contributing to lower credit demand from traded sector goods producers. Although there is no

²³The model is solved log-linearizing the equilibrium conditions around the non-stochastic steady-state.

heterogeneity in the banking sector assets, a decline in the friction of cross-border deposits create an intra-national imbalance as well as an international imbalance. This is what I call the *trade channel*.

The trade channel is also prevalent in the baseline model, as credit expansion to non-traded sector is larger than the ratio of $\frac{\lambda_{NT}}{\lambda_T}$. In the baseline, when non-tradable sector credit spreads decline in a more pronounced way, non-traded sector firms demand more credit, relative prices in Home fall, households shift their consumption to imported goods, enforcing further downward pressure on the size of traded sector during the boom. *Banking channel* (i.e. $\lambda_{NT} > \lambda_T$) reinforces *trade channel*.

During the bust, there is an instantaneous intra-national rebalancing leading to a one time hike in the traded output, under the baseline model. This effect is not present in other two versions as the credit spreads move equally. When the sudden stop of cross border bank finance induces positive spreads in the non-traded sector, firms in traded sector demand more credit as it becomes relatively cheaper. However, this effect fades away as the cost of credit is still above its steady state value during the bust periods.

Finally, it is observed that under the low lambda model, trade channel works through the opposite direction. Movements in μ_t offset the opposite movement in ι_t , creating a negative spread between Foreign and Home deposits in Home bank balance sheets. Increase in Home relative interest rate makes Home goods relatively cheaper and households decrease imports, increase exports, contributing to a larger growth in the traded sector.

4. Unconventional Central Bank Policies

A central bank, constrained by the zero-lower-bound, can intervene in markets by increasing demand on non-financial private sector assets, or by supplying further funding to the banking sector to overcome the restriction on the size of banks' portfolio of assets over their internal equity.

The policies that I am studying here are different than those in the recent literature by the choice of funding for intervention—resources for intervention are raised from banks instead of from households—, by its response to sector specific variables, and by its conduct in an international environment inducing public capital flows. The assumption of the unconventional policy financed by interest-bearing reserves is in line with the evidence obtained from the Eurosystem balance sheet, which exhibits an increase in deposit liabilities of the Eurosystem from Monetary and Financial Institutions (MFIs) after the start of the ECB unconventional policies in early 2008, indicative for the resources of the ECB firepower.

In what follows, the policy applications are examined in greater detail.

4.1. Asset Purchases

After the financial crisis, ECB started its private asset purchase program as a mean of using its powers as a lender of last resort. The relevant ECB announcement²⁴ indicated that these policies were mainly targeted toward acquiring non-traded sector assets.

Building motivation from this case, I assume that a global central bank has the option of intermediating a fraction $\varphi_{T,t}^{ump}$ of total domestic tradable, and a fraction $\varphi_{NT,t}^{ump}$ of non-tradable sector funding needs. In particular, now the central bank can purchase $S_{T,t}^g \equiv \varphi_{T,t}^{ump} S_{T,t}$, or $S_{NT,t}^g \equiv \varphi_{NT,t}^{ump} S_{NT,t}$, in fractions of total sectoral assets. The private assets intermediated by the financial intermediaries are denoted with $S_{T,t}^p \equiv (1 - \varphi_{T,t}^{ump}) S_{T,t}$, and $S_{NT,t}^p \equiv (1 - \varphi_{NT,t}^{ump}) S_{NT,t}$, respectively. Deviating from the previous literature, I specify the fractions of the assets intermediated by the central bank as autoregressive processes with an innovation that occurs at the same time of the sudden reversal of capital flows, at $t = 33$. That is:

$$\hat{\varphi}_{i,t}^{ump} = \rho_{\varphi_i^{ump}} \hat{\varphi}_{i,t-1}^{ump} + u_{i,t}^{ump}, \quad (27)$$

with $i \in \{T, NT\}$.²⁵ Capped variables indicate the deviations from their non-stochastic steady-state.

To finance these purchases, central bank issues debt to banks at rate $R_{g,t+1}$, and banks fund this activity by issuing deposits to Home and Foreign households at the risk-free rate. The rate $R_{g,t+1}$ is the interest that will be paid by central bank to the financial intermediary between periods t and $t + 1$, and it is known in period t . Central bank's balance sheet takes the following form:

$$Q_{T,t} S_{T,t}^g + Q_{NT,t} S_{NT,t}^g = B_t^g + \xi_t B_{*,t}^{*g}.$$

In this setting, B_t^g and $B_{*,t}^{*g}$ can be thought of as interest bearing reserves of Home and Foreign intermediaries at the central bank's account. In equilibrium, the global central bank raises equal amount of resources from each

²⁴See Decision ECB/2014/45, November 19, 2014.

²⁵I also choose $\rho_{\varphi_i^{ump}}$ to ensure that the central bank balance sheet is sterilized in 12 years.

country (*i.e.* $B_t^g = \xi_t B_{*,t}^{*,g}$), as the sizes of the countries are equal to each other. Moreover, following the previous literature, I introduce inefficiency costs of τ_T and τ_{NT} per unit of private funding intermediated in each sector. If banks' constraints are not binding, these costs make the central bank intervention inefficient.

Now, the financial intermediary balance sheets become

$$\underbrace{Q_{T,t}S_{T,t}^p(j) + Q_{NT,t}S_{NT,t}^p(j)}_{\text{Private Assets}} + \underbrace{B_t^g(j)}_{\text{Interest-Bearing Claims}} = \underbrace{B_{t+1}(j) + B_{t+1}^*(j)}_{\text{Liabilities}} + \underbrace{N_t(j)}_{\text{Bank Capital}}, \quad (28)$$

with the incentive constraint now also indicating the banks' ability to divert central bank debt in the case of default:

$$V_t(N_t(j)) \geq \lambda_T[Q_{T,t}S_{T,t}^p(j) - \iota_t B_{t+1}^*] + \lambda_{NT}[Q_{NT,t}S_{NT,t}^p(j) - \iota_t B_{t+1}^*] + \lambda_{ECB}B_t^g(j), \quad (29)$$

Here, it is easier for Home depositors to monitor the performance of central bank debt than the performance of private asset portfolios, and hence, the former is subject to a lower degree of bank malfeasance. In particular, in the quantitative analysis of this section, *w.l.o.g.* I assume $\lambda_{ECB} \equiv \frac{\lambda_T}{2}$.

4.2. Liquidity Facilities

An alternative unconventional policy that is more reminiscent of the LTROs²⁶ of the ECB is liquidity facilities conducted by the common central bank in the model. Under this policy alternative, the central bank lends funds to financial intermediaries, which in turn will lend to non-financial private firms.

I assume that the central bank provides non-contingent funding, M_{t+1} , to banks, at a rate, $R_{m,t+1}$, which is known in period t . Financial intermediary balance sheets take the following form

$$Q_{T,t}S_{T,t}(j) + Q_{NT,t}S_{NT,t}(j) + B_t^g(j) = B_{t+1}(j) + B_{t+1}^*(j) + \underbrace{M_{t+1}(j)}_{\text{Discount Window Lending}} + N_t(j). \quad (30)$$

The financial intermediary's non-tradable sector firm assets and interest bearing reserves are eligible collateral for the central bank liquidity facilities. Hence, for any unit of discount window lending, a borrowing bank cannot divert any of those assets:

$$V_t(N_t(j)) \geq \lambda_T[Q_{T,t}S_{T,t}(j) - \iota_t B_{t+1}^*(j)] + \lambda_{NT}[Q_{NT,t}S_{NT,t}(j) - \iota_t B_{t+1}^*(j) - M_{t+1}] + \lambda_{ECB}(B_t^g(j) - M_{t+1}(j)). \quad (31)$$

Liquidity facilities will loosen the binding constraints, depending on whether the relaxation induced by liquidity injection offsets the additional friction borne from the divertibility of interest bearing claims.

Finally, the magnitude of liquidity facilities are determined by a similar rule as in the case of private asset purchases, yielding to the following relationship:

$$M_{t+1} = \varphi_{T,t}^{ump} Q_{T,t}S_{T,t} + \varphi_{NT,t}^{ump} Q_{NT,t}S_{NT,t}, \quad (32)$$

where $\varphi_{T,t}^{ump}$ and $\varphi_{NT,t}^{ump}$ are given by (27).

4.3. Experiments under Unconventional Central Bank Policies

I conduct simulations, with $\varphi_{T,t}^{ump} = 0$ and $\varphi_{NT,t}^{ump}$ initiates in 2008:Q1 at the same time with the sudden reversal of capital flows. I set the magnitude of the unconventional policy to 5, implying an absolute deviation of 500 from zero.²⁷ Hence, I investigate the policy's contribution to model performance when it is conducted in response to non-traded sector variables.

Figure 3 exhibit the model's performance with respect to the Spanish data, when the combination of central bank asset purchase program and liquidity facilities is in place. As discussed in section 3.2.2, including policy in the model improves the model's post-crisis performance. The collapse in bank credit toward non-tradable sectors is less pronounced because policy is strong enough to take the credit spreads to the negative territory and making non-traded sector credit cheaper again vis-à-vis to traded sector credit. Global central bank is channeling funds from Foreign to Home and private capital outflows are partially replaced by public capital inflows. Because there

²⁶To address the illiquidity issues in the financial sector of the Eurozone, the first supplementary longer-term refinancing operation (LTRO) of ECB with a six-month maturity was announced in March 2008. Between April 2008 and October 2011, the ECB conducted twenty LTROs with six-month maturity. Details of the ECB's announcements can be found in their website: <https://www.ecb.europa.eu/mopo/implement/omo/html/index.en.html>

²⁷This is within the range of the values used in the literature. For instance, GKa conduct experiments with a response coefficient of 100, where as Dedola, Karadi, and Lombardo (2013) use a response coefficient of 400 for each central bank in a two-country model.

are only two countries in this setting, due to jump in private and public capital flows, current account becomes uninformative vis-à-vis to the data under UMP.

Although the collapse in bank lending is improved under policy, it is still more severe than in the data. This is probably due to abstracting from regulatory measures taken by Spanish authorities during the post-crisis period.²⁸ Moreover, in the model, there are no frictions between intermediaries and firms, which implies efficient credit flows. In the presence of frictions between intermediaries and firms, it is possible to observe firm overborrowing.

Finally, Figure 4 compares the dynamics under central bank asset purchases (AP) with liquidity facilities (LF). The figure shows that AP are slightly better at ameliorating the economy when equal amount of central bank fire-power is in place under both options. There are two counter-acting effects in efficiency of AP over LF. First effect is due to the design of the information asymmetry: financial frictions are between households and bankers, and there are no frictions between firms and banks. Hence, for any additional unit of funding one would expect an efficient allocation of credit across sectors and LF to be more effective than AP. However, there is another effect under the case in this paper. With the magnitude of these policies taking bank Lagrangian multiplier to negative territory, spreads between central bank liquidity rate and risk-free rate become negative. Negative spreads imply central bank funding being cheaper than private deposits, and hence crowd out private deposits in the bank balance sheet. This is violation of Bagehot (1873) principle: “Central bank liquidity should be extended against eligible collateral and at a penalty rate.” Violation of Bagehot (1873) leads to AP being more effective in ameliorating the economy than LF.

5. Conclusions

A quantitative, two-country, macroeconomic model in which banks face endogenous leverage constraints is developed to study the role of the financial sector in affecting domestic resource allocation and cross-border capital flows. International financial integration through bank balance sheets amplify and propagate fluctuations through *banking* and *trade* channels that reinforce each other. The results are relevant because the recent consensus narrative on the Eurozone crisis (e.g., Baldwin and Giavazzi, 2015) suggests a similar view: “Capital flows tended to feed non-tradable sectors in the periphery of the Eurozone, and when the investors lost trust in deficit nations, the effects of a sudden-stop were amplified due to the predominance of bank financing.” This paper contributes to this debate by providing a rigorous framework for this consensus view. I further showed that unconventional policy that is reminiscent of the ECB’s is effective at ameliorating the economy.

6. References

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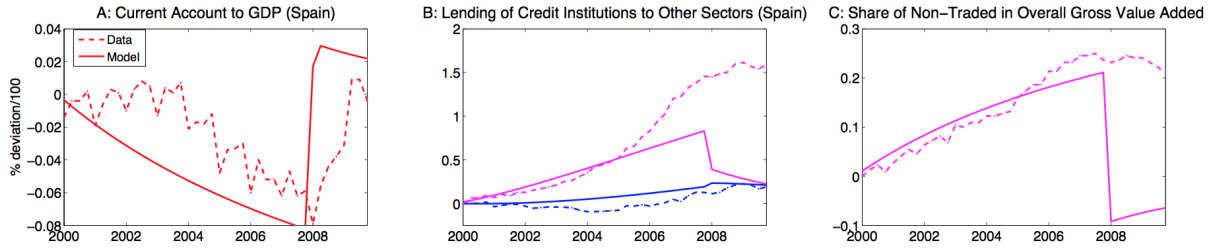
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²⁸Spanish authorities introduced several measures to improve the financial system between 2008-11. In 2008, Fund for the Acquisition of Financial Assets is created, deposit guarantee scheme is reformed, in 2009, Orderly Restructuring of the Banking Sector is established, and in 2010, savings banks sector reforms are introduced. See Bank of Spain (2017).

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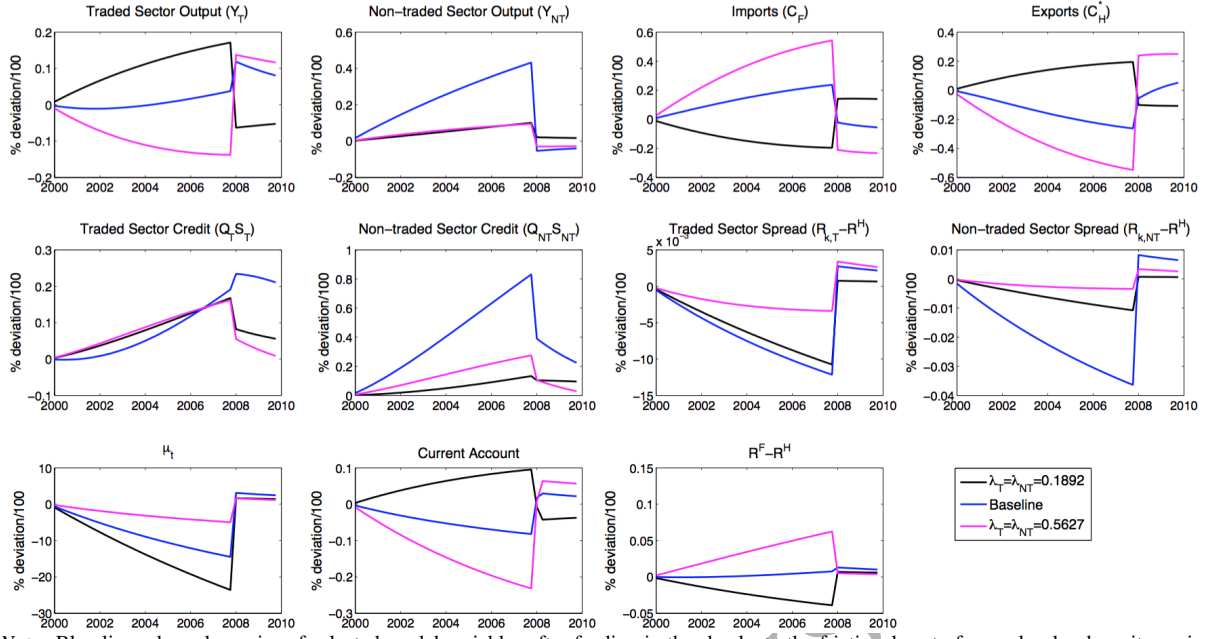
556 **Figures**

Figure 1: Model and Data



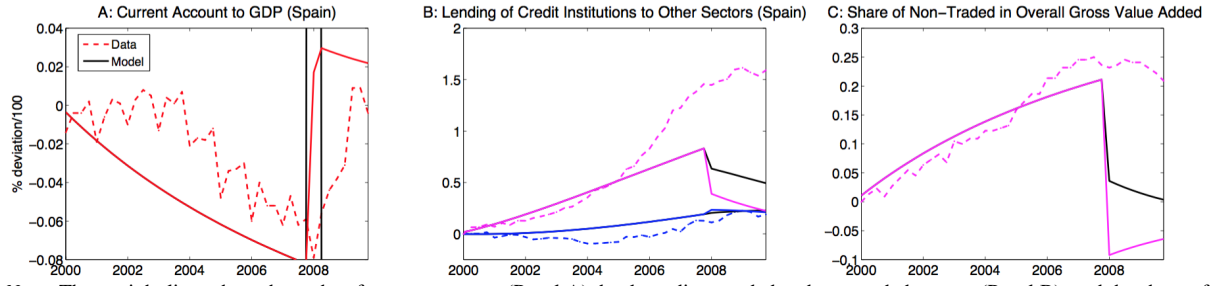
Note: The straight lines show the paths of current account (Panel A), bank credit to traded and non-traded sectors (Panel B), and the share of non-traded sector in overall production (Panel C) after feeding in the shocks to the frictional cost of cross-border bank deposits, ι_t , in the model. Dashed lines show the data of Spanish current account-to-GDP (Panel A), percent deviation of bank lending to non-financial sectors from 1999:IV (Panel B), and the share of non-traded sectors in overall gross value added as percent deviations from its 1999:QIV value (Panel C).

Figure 2: Heterogeneity in Bank Assets and International Trade



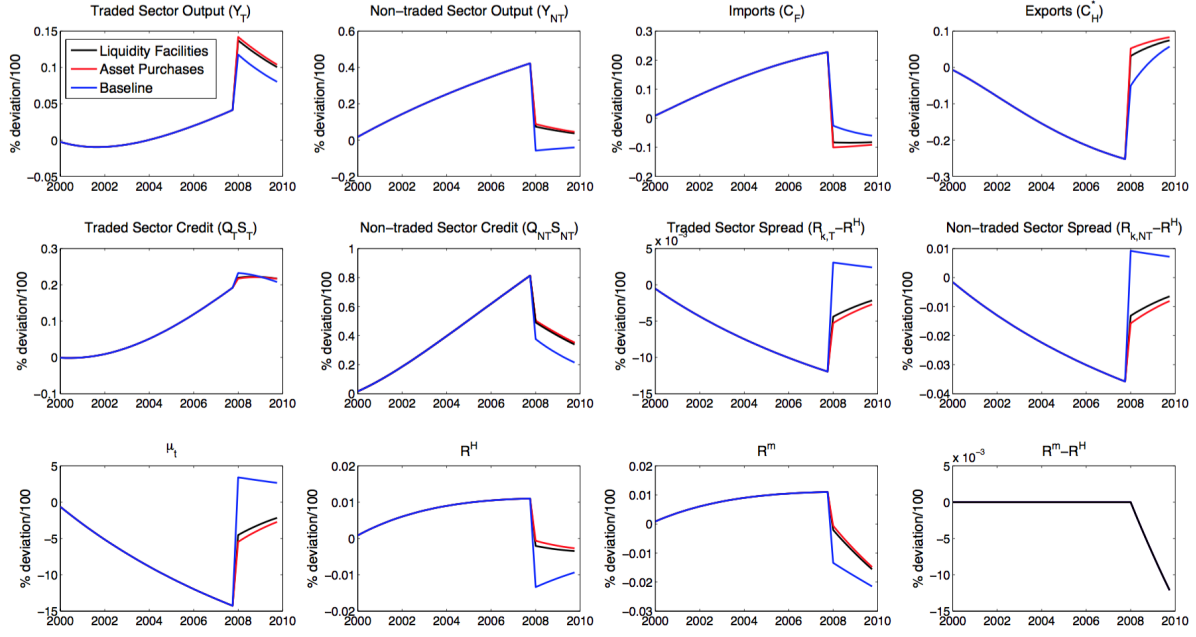
Note: Blue lines show dynamics of selected model variables after feeding in the shocks to the frictional cost of cross-border deposits, u_t , in the baseline model. Black lines show dynamics from the model when banking sector parameters are set such that $\lambda_T = \lambda_{NT} = 0.1892$, all else being the same. Purple lines show dynamics when $\lambda_T = \lambda_{NT} = 0.5627$, all else being the same.

Figure 3: Model and Data with Unconventional Policy



Note: The straight lines show the paths of current account (Panel A), bank credit to traded and non-traded sectors (Panel B), and the share of non-traded sector in overall production (Panel C) after feeding in the shocks to the frictional cost of cross-border bank deposits, τ_f , in the model. Straight black lines show the model performance when unconventional policies are in place. Dashed lines show the data of Spanish current account-to-GDP (Panel A), percent deviation of bank lending to non-financial sectors from 1999:IV (Panel B), and the share of non-traded sectors in overall gross value added as percent deviations from its 1999:QIV value (Panel C).

Figure 4: Comparison of Unconventional Policies



Note: Blue lines show dynamics of selected model variables after feeding in the shocks to the frictional cost of cross-border deposits, ι_t , in the baseline model. Black lines show dynamics from the model when liquidity facilities are in place during the bust, whereas red lines show dynamics under asset purchases program of the global central bank.

557 **Tables**

Table 1: Parameter Values

<i>Parameter</i>	<i>Value</i>	<i>Comments</i>
Discount factor	β 0.995	Standard RBC value
Risk aversion coefficient	ρ 2	Standard RBC value
Relative weight of labor in the utility	ϖ 5.584	Gertler and Kiyotaki (2010)
Inverse Frisch elasticity (T sector)	φ_1 0.276	Gertler and Karadi (2011)
Inverse Frisch elasticity (NT sector)	φ_2 0.276	Gertler and Karadi (2011)
Deposit adjustment	η 0.0025	Standard RBC value
Inverse elasticity of substitution between Home and Foreign goods	ω 1.2	Standard RBC value
Inverse elasticity of substitution between traded and non-traded goods	κ 1	Obstfeld and Rogoff (2000)
Investment adjustment	φ^K 5	Bernanke, Gertler, and Gilchrist (1999)
Depreciation	δ 0.025	Standard RBC value
Home bias	a_H 0.55	To match data properties
Share of tradable sector	a_T 0.55	To match data properties
Share of capital in production	α 0.33	Standard RBC value
Exit probability of intermediaries	γ 0.975	Bank survival of 10 years
Fraction of start-up funds	ε 0.0001	Small effect of banker entry-exit
Tradable sector asset diversion	λ_T 0.2185	To match a steady-state spread in
Non-tradable sector asset diversion	λ_{NT} 0.6556	NT sector of 120 bps, in T sector of 40bps, when leverage ratio is 6.